





AN  
INTRODUCTION

TO THE  
S T U D Y

OF THE  
*ANIMAL ECONOMY;*

TRANSLATED FROM THE FRENCH OF

*CUVIER,*

By JOHN ALLEN,

FELLOW OF THE ROYAL COLLEGE OF SURGEONS,  
AND LECTURER ON THE ANIMAL ECONOMY,  
AT EDINBURGH.

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1801.



TO THE GENTLEMEN

ATTENDING HIS LECTURES ON THE

ANIMAL ECONOMY,

THE FOLLOWING TRANSLATION,

UNDERTAKEN FOR THEIR USE,

IS,

WITH SINCERE WISHES FOR THEIR WELFARE,

INSCRIBED BY

THE TRANSLATOR.



## ADVERTISEMENT.

THE following observations, on the Animal Economy, are extracted from the introduction to a work, published about eighteen months ago at Paris, under the title of *Leçons d'Anatomie comparée de G. Cuvier*. As they appeared to the Translator to convey a more correct idea of the essential attributes of life, and to afford a more comprehensive view of the relations that subsist between the different functions of the Animal Economy, than any work which he had seen, he was induced, for the reason mentioned in the Dedication, to attempt the translation of them into English. He has annexed a very few Notes to the last chapter, for the sake of those who might wish to compare the arrangement of *Cuvier* with that of *Linnæus*; but, as the translation was intended for the use of Students of Physiology, and not for Naturalists, he has suppressed the subordinate divisions of *Cuvier*, and omitted entirely the tables of genera which are annexed to the original work.

The Translator has to apologise for several Gallicisms and other inaccuracies, which, from the haste with which the translation was originally executed, had insinuated themselves into his version, and which escaped him while correcting it for the press. Some of these inaccuracies which appeared to alter or obscure the meaning, he has endeavoured to correct in the table of Corrigenda, placed at the end.

## INTRODUCTION





# INTRODUCTION

## TO THE STUDY OF THE

### ANIMAL ECONOMY.

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#### CHAP. I.

##### *A General View of the functions exercised by Animals.*

THE idea of *Life* is one of those vague and obscure ideas suggested to us by the observation of phenomena that succeed in regular and corresponding trains. Though unable to discover the nature of the relation between these trains of phenomena, we are satisfied of its existence; and this is sufficient for us to class them together, and distinguish them by an appropriate term, which the vulgar mistake for the name of a particular Agent or Principle; whereas, it is merely a general expression for the phenomena, that suggested the formation of the term.

Thus, having observed in our own bodies, and in many bodies analogous to our own in form and structure, a power of resisting, for a certain period, the laws which regulate unorganized

unorganized bodies, and even of acting upon other bodies in opposition to these laws, we employ the terms *Life*, *Vitality*, *Vital power*, to express these apparent exceptions from the ordinary course of Nature. To affix an exact meaning to the terms *Life*, *Vitality*, and *Vital power*, we must, therefore, determine exactly in what these exceptions consist. Let us for that purpose consider the bodies in question, in their active and passive relations to the rest of Nature.

Take for an example; the Female form, in the fulness of youth and health; observe that rounded and voluptuous swell of the limbs; that graceful ease in motion; that balmy warmth; those cheeks tinged with the roses of health; those eyes beaming with love, or sparkling with intelligence; that countenance enlivened by wit, or animated by feeling; every thing combined to form an object of fascination. A single instant suffices to dispel the charm: often, without an apparent cause, sensation and motion cease at once; the body loses its warmth; the muscles become flaccid, and disclose the prominent angles of the bones; the eyes lose their lustre; the lips and cheeks become livid. These are but the preludes to changes more hideous. The colour passes successively to a blue, a green, a black; the flesh absorbs moisture; and while one part of it escapes in pestilential exhalations

halations, the remaining part falls down into a putrid, liquid mass. In a short time no part of the body remains, but a few earthy and saline principles; its other elements being dispersed through air, or carried off by water, to form new combinations.

This decomposition of the body after death is the natural effect of the air, moisture, heat, and other external powers; and is occasioned by the chemical affinities of these agents for the elementary or constituent parts of the body. Yet, the body when alive had been surrounded by the same external agents, which had exerted upon it the same affinities; so that a similar decomposition must have taken place during its living state, if the elements composing it had not been kept together by a superior force, that ceased to act upon them at the instant of death.

Of all the phenomena included in the general idea of Life, this then, is one which appears at first sight the most essential to it; since it is inconceivable, that a living body should continue to exist, without the means of resisting decomposition; and in fact, we observe this preserving power exerted without interruption to the very instant of death.

But farther attention to the economy of living bodies soon discovers to us, that the  
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power, which keeps together their elementary parts, in opposition to the external forces that tend to decompose them, is not confined to this negative operation, but extends its activity beyond the boundaries of the living body. There is at least no reason for supposing any difference between this preserving power, and that which attracts particles extrinsic to the living body, and interposes them between its integrant parts; nor is the action by which foreign particles are introduced into the living body less uninterrupted than that by which its own particles are apparently kept together. For, not only is the absorption of alimentary matter, and its subsequent passage into the nutritive fluid, and its conveyance by the nutritive fluid to the different parts of the body, carried on with hardly any interruption, from one meal to another; but there is a continual absorption from the surface of the body, and a third kind of absorption equally constant, depending on respiration. These two last are indeed the only kinds of absorption, in living beings, which are without organs of digestion; that is, in plants.

But, since the growth of living bodies is not indefinitely great, Nature having assigned to them limits which they cannot exceed, they must necessarily lose on the one hand a great part at least of what they receive upon the other; and in fact observation has shown, that perspiration and a variety of other means are continually



continually abstracting from them a part of their substance.

This consideration leads us to modify our original idea, with respect to the nature of that power, by which living bodies are preserved from decomposition. Instead of an uninterrupted union in the same particles of living matter, we discover a continual circulation proceeding without interruption, and yet fixed down within certain limits. In this view of living bodies they may be compared to so many eddies or whirlpools, into which inanimate materials are continually drawn ; where they are combined together in various forms, detained for a certain time, and applied to different uses ; but from which they are at last thrown out, and restored to the laws of unorganized matter.

It is necessary to add, that the proportion between the quantity of matter passing into this current and the quantity discharged from it, is liable to variations depending upon age and health ; and that the general velocity of the circulation varies according to the nature and condition of every living being.

It appears also, that life as naturally terminates in death, as other kinds of motion in rest ; and that the gradual induration of the living fibres, and obstruction of the living vessels, would render death the necessary consequence of life, though  
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it were not accelerated by a multitude of accidental causes.

This general and common motion in all the parts of a living body is so much the essential attribute of life, that parts, separated from the body, die speedily, because they contain not within themselves any principle of motion, and only participate in the general motion which is produced by their union into an organized whole ; so that, to use the language of Kant, it depends on the living body as a whole, what mode of existence shall belong to its different parts ; whereas, among unorganized bodies, the mode of existence of every part depends solely upon itself.

This essential attribute of life having been once deduced from the constancy of its effects, it is natural to inquire into its origin, and how it is communicated to the bodies which it animates. For this purpose Philosophers have gone back to the infancy of living bodies, and endeavoured to trace them as near as possible to the first instant of their formation : but living bodies are hid from our inspection, till formed, in the exercise of life, and in the midst of that vortex of which we seek to discover the origin. However small the parts of an embryo or of a seed, when first visible to us, they are already in full possession of life, and contain already the  
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germ of all the phenomena, which through the means of life they are afterwards to develop. Such inquiries, having in every class of living bodies had the same result, lead to this general conclusion, that, there is no living body, which was not at one time part of another living body, from which it has been since detached; that, every living body has participated in the life of another living body, before it was capable of carrying on living motion by itself; and, that from the living power of the body to which it originally belonged, it derived that degree of developement, which rendered it susceptible of independent life. The vital motions of living bodies have, therefore, their real origin in the parent stock. It is from the Parent that the Offspring receive the vital impulse; life springs from life only; nor is there an example of living power, which has not been transmitted from one living body to another, in uninterrupted succession.

Since we are, then, unable to trace life back to its origin, we have no other means of ascertaining the real nature of the living powers, but by examining the structure and composition of living bodies, for though it be true that these are in some measure the effects of the living powers, which formed and which support them, still it is equally clear that the living powers can have no other source or foundation but in  
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the body in which they inhere. If the chemical and mechanical elements of the body were originally combined by the living power of its parent, there must be the same living power in the body itself, since it exercises a similar action in favour of its descendants.

But, our knowledge of the structure and composition of living bodies is too imperfect to enable us to explain from it their functions. We see, in general, that they are made up of fibres or laminæ, so as to form a series of network, more or less close, and constituting the basis of all the solids, as well of those which have a sensible degree of thickness, as of those which are mere membranes or filaments. We are acquainted with the figure, consistence, and position of such of the solids as have any sensible magnitude; we can follow out the more considerable ramifications of the vessels, and know the course of the fluids which they convey; but the more delicate branches of the vessels, and the intimate texture of the solids are too fine for our instruments. In the same manner we have a general acquaintance with the more prominent chemical characters of both the solids and fluids; we can decompose them to a certain point; yet, not only is this analysis imperfect, since we cannot recombine them; but there are phenomena which indicate the presence of subtle matters in living animals, which we have



we have not yet been able to bring under our examination.

In the mean time though Philosophers have not been successful in their endeavours to connect the phenomena of life with the general laws of matter, it would be rash to infer that they are of a different kind; and, on the other hand, it would be fruitless to renew the attempt, while our knowledge of living bodies remains so limited. We must, therefore, content ourselves at present, with an empirical in place of a systematic exposition of the functions of life, and confine our labours on the economy of organized beings to a delineation of the phenomena.

But, though our knowledge of the composition of living bodies be insufficient to explain the phenomena which they exhibit, it will, at least, enable us to recognise them when not in action, and to distinguish their remains long after their death. For no unorganized body presents us with that fibrous or cellular texture, nor with that multitude of volatile elements which continue to be the characteristic marks of organized bodies after their vital powers have ceased.

For example, unorganized bodies are composed of polyhedral particles, which attract one another by their surfaces, and preserve their respective distances unchanged, unless separated by

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some extrinsic force ; while organized bodies are constructed of flexible fibres or laminæ, inclosing spaces filled with a fluid. Unorganized bodies are resolvable into a small number of fixed substances, which our instruments are unable farther to decompose, while organized bodies are resolved almost entirely into elastic fluids. Unorganized bodies are produced by the chemical union of their elements, and by the subsequent aggregation of the particles of the compound ; while organized bodies derive their origin from bodies similar to themselves, to which they were at first attached, and from which, when sufficiently developed to support themselves, they were afterwards separated. Unorganized bodies increase by the juxtaposition of new particles, which, forming layers, envelope the previously existing mass ; while organized bodies are continually assimilating foreign materials by intussusception, and thus grow by an internal force. Lastly, unorganized bodies are not liable to destruction, unless by some mechanical agent that separates their particles, or by some chemical power that alters their composition ; while organized bodies perish from an internal cause, death being a necessary consequence of life.

An origin by *generation*, an increase by *nutrition*, a termination by *death*, are then the general and common characteristics of all organized beings.

Many

Many organized bodies exercise no functions, but those subservient to the general functions of nutrition and generation; and possess no organs, but those required for the exercise of these functions. But in a great number of organized bodies, there are functions carried on of a subordinate nature, which not only demand appropriate organs, but which influence the economy of these general functions, and modify the structure of the organs by which they are exercised.

Of these subordinate functions, which imply organization, but are not the necessary consequence of its existence, the faculties of sensation and of voluntary motion are the most important, and have the greatest influence upon the economy of the other functions.

We are conscious that these faculties belong to ourselves, and, judging from analogy and from external appearances, we attribute them to a great number of other beings, whom, on that account, we call *animated* Beings, or in a single word *Animals*.

There seems to be a necessary connection between these two faculties. In the first place, the very idea of voluntary motion implies sensibility; for, it is impossible to conceive volition without desire, or without the sensation of pleasure

ture and of pain. It is true, that some inanimate bodies perform very conspicuous motions proceeding from an internal principle; but these motions are of the same nature with those which carry on the essential functions of Life, and deserve not the name of voluntary.

In the second place, the benevolence of Nature, so conspicuous in all her works, forbids us to believe it possible, that she could have constructed sentient beings, susceptible of pleasure and of pain, without imparting to them the smallest power of pursuing the one, or of flying from the other.

But, independently of the necessary connection between sensation and voluntary motion, and the double apparatus of organs required for exercising these faculties, they lead to several important modifications in the functions common to all organized beings. In these modifications, and in the two faculties themselves of sensation and voluntary motion, consist the peculiarities of animal life.

To take nutrition as an example; vegetables, which are attached to the soil, absorb, by their roots, the nutritive particles of the fluids that moisten the earth. The minute subdivisions of the roots penetrate into the smallest intervals of  
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the clod, and go in search of nourishment for the plant to which they belong. Their action is tranquil, continual, and interrupted only by the dryness of the soil.

Animals, on the contrary, having no attachment to the soil, but possessing the locomotive faculty, require to possess the means of transporting along with themselves the provision of juices necessary for their support. Accordingly, an internal cavity is given to them, within which they deposit substances proper for their nourishment, and in the coats of which are placed absorbing orifices, or, as they are called in the expressive language of Boerhaave, the *internal roots* of the animal. The magnitude of this cavity, and the width of the passages leading to it, admit, in many animals, the introduction of solid substances. Instruments then become necessary for the division, and liquids for the solution of aliment. The beginning of nutrition ceases to be the mere absorption of fluid matter from the soil or atmosphere. It must be preceded by a number of preparatory operations, which, taken together, form what is called *Digestion*.

Digestion is then a function of a secondary order, and, together with the alimentary canal within which it is carried on, peculiar to animals; but though a necessary sequel to the locomotive faculty

faculty of animals, it is not the only consequence to which that faculty leads.

Vegetables being limited to a small number of faculties, require a very simple organization. They are constructed almost entirely of parallel or slightly diverging fibres. The fixedness of their position renders external agents sufficient to preserve in motion the fluid by which they are nourished. Accordingly it ascends from the roots to their branches, by the attraction of their spongy and capillary texture, and by the evaporation from their summits ; its ascent is more rapid as the evaporation is increased, and its motion becomes even retrograde, when, from the coldness or humidity of the air, the evaporation ceases, or is succeeded by absorption.

Animals, being destined for a continual change of place, and fitted to exist in every situation and every climate, require within themselves an active principle, to communicate motion to the fluids by which they are nourished. Because the faculties of Animals are more numerous and more varied than those of vegetables, they require a more complicated system of organization, and consequently possess a greater variety of parts, more complex in their forms, more diversified in the arrangement of their fibres, and susceptible of far greater latitude of motion. To convey the nutritive fluid into so many winding passages as  
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this conformation implies, demands a more considerable force and a less simple mechanism than that which suffices for vegetables.

Accordingly, in the greater number of Animals, we find the nutritive fluid contained within innumerable canals, branching from two principal trunks, the communication of which is such, that the one, after receiving into its roots or beginnings, the fluid which the other had carried forward into its branches, brings back this fluid to the centre of the body, from which it is again sent to the extremities.

At the place where the two large trunks communicate, the heart is situated, which, by an exertion of its contractile power, expels from its cavities the nutritive fluid, and drives it forward into the arteries; for, there are two valves placed at the two orifices of the heart, which confine the motion of the fluid in the vascular system to one particular direction; that is, in the direction from the heart to the extremities by the arteries, and in the direction from the extremities back to the heart by the veins.

This motion, in a circle, is called the Circulation of the blood, and is another function of a secondary order peculiar to animals, regulated and principally supported by the heart. But, the circulation is less inseparably connected with  
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sensation and voluntary motion than digestion is ; for, two numerous classes of animals are entirely destitute of circulation, and nourished, in a manner somewhat like vegetables, by the transudation of the fluid which is prepared in their alimentary canal. †

In animals where a circulation is found, the circulating blood appears to be a mere vehicle of nutritive particles, receiving continually from the alimentary canal, from the surface of the body, and from the lungs, various substances which it incorporates in the most intimate manner, and by which it replaces those particles which it had furnished to the different parts of the body for their nourishment and growth. It is in the passage of the blood through the extreme branches of the arteries, that it contributes directly to the nourishment of the solids, and where at the same time it changes its nature and its colour ; nor is it till after the addition of the substances which have just been mentioned, that the blood recovers its power of nourishing the solids and is reconverted into arterial blood.

A particular set of vessels, called the Absorbents, convey to the venous blood those substances which it receives from the skin and from the alimentary canal ; and the same vessels bring back to it what remains of the secretions  
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† The class of Insects and the class of Zoophytes.



after performing their office, as well as the particles which are separated from the solids, in order to be conveyed out of the body by the different emunctories.

With regard to the pulmonary system, the air which penetrates into the cavity of the lungs, maintains in the venous blood a species of combustion, which appears to be essentially necessary to the life of organized beings; since it takes place, though by different means in all. Vegetables, and animals destitute of circulation, respire by the whole of their external surface, or by particular vessels that convey air into the different parts of their interior. But, animals which have a true circulation, are enabled to respire by a particular organ; for, the blood flowing continually to and from the heart, can be confined in vessels, arranged in such a manner that the blood in its way from the heart to the extremities, shall necessarily pass through the lungs. This arrangement is obviously impracticable in animals, where the nutritive fluid is diffused every where in a uniform manner, and not contained in vessels.

Thus, respiration by lungs or gills is a function of a third order; for its existence depends on that of the circulation. It is at the same time a remote consequence of the faculties that characterize animal life.

The mode of generation too, in animals, is regulated by their peculiar functions, at least in so far as relates to the fecundation of germs. Possessing sensibility and the locomotive faculty, animals are distinguished from vegetables by their capacity for the enjoyments of love; and with respect to the mechanism of impregnation, their spermatic fluid can be directly applied to the germs; whereas, in vegetables, which are without the means of darting this fluid into its proper receptacle, it is necessary to inclose the pollen in small capsules, within which it may be transported safely by the winds. Thus, while the peculiar functions of animals have procured for them a more complicated apparatus for the greater part of their functions, they allow generation to be exercised by animals in a more simple manner than by vegetables.

These examples will serve to illustrate how much the two faculties of sensation and voluntary motion, peculiar to animals, influence their structure and economy, even in those functions which are common to them with vegetables. It will afterwards appear, when we compare together the different orders of animals, that any modification of one of the principal functions has a similar influence on all the collateral functions: so great is the mutual agreement and harmony between the different parts of a living body.

Such

Such are the principal functions of the animal economy. It is obvious that they may be reduced under three different orders.

The first will consist of the functions which are essential to animal life, which qualify animals to fulfil the part assigned to them by nature in the general arrangement of the Universe; and which would suffice for their existence, if their existence were to be of only momentary duration. To this class belong the faculties of sensation and of voluntary motion. The one enables animals to perform certain actions; and the other determines them to the particular actions which they perform. Every animal may be considered as a particular machine, having certain fixed relations to all the other machines, that together form the Universe. The immediate organs of motion are the pulleys, the levers, the passive parts of this machine; but, the active principle, the spring which gives impulse to the whole, resides in the sensitive principle, without which the animal, sunk in perpetual sleep, would be degraded to the condition of a vegetable; or a vegetable may be called in the language of Buffon, a sleeping animal. Sensation and voluntary motion form then the first order of functions, and are termed the *animal functions*.

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But, animated machines differ from those of human contrivance, in possessing an internal principle of support and reparation ; and to this principle are subservient all the functions which contribute to the nourishment of the body ; that is, digestion, absorption, circulation, respiration, perspiration, and excretion. These functions form together the second order, or the *vital* functions.

In the last place, the life of animals having fixed limits, that vary according to the species, *generation* is a function of a third order, destined to supply new individuals in the place of those who are removed by death, and thus to perpetuate the existence of every species of animals.

After these general reflections on the functions of animals, and on their mutual relations to one another, we shall proceed to consider the organs by which they are carried on.



## C H A P. II.

### *General idea of the ORGANS which compose the body of an ANIMAL.*

NO part of an animal body consists entirely of solid particles. Every part affords fluids by expression or exsiccation ; and every part has a reticulated texture, like network.

The mechanical division of the body, when carried to its greatest extent, conducts us to small laminæ or filaments, which seem to be the elementary basis of the solids. When these small laminæ are separated from one another, and inclose a sensible space, they form what is called the cellular substance. Every part of the body is surrounded and penetrated by cellular substance, and many of the densest parts are composed of it entirely. The membranes, for example, are nothing but condensed cellular substance, the plates of which are closer than elsewhere, and more exactly applied over one another ; and, by maceration, they are resolvable into the common loose cellular texture. Vessels are membranes formed into cylindrical tubes ; and, all the soft parts of the body, except the fibres, are an assemblage of vessels, differing in  
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the fluids which they convey, in their number, in their course, and in the thickness of their coats.

The chemical analysis of these substances, solid as well as fluid, discovers to us a small number of chemical elements, which, combined in different proportions, form the different species of animal matter. Some earths, some salts, phosphorus, carbon, azote, hydrogen, oxygen, small quantities of sulphur, and of iron, constitute, by their various combinations, the different animal compounds, such as gelatin, albumin, fibrin, &c. ; and, these again, uniting among themselves, form the different animal solids and fluids which we find in nature. But, we are far from possessing a complete analysis of animal matter. There are many animal substances which we cannot procure in a separate state, without first altering their nature ; and, we have reason to believe, that there are elementary substances in animals which have hitherto escaped us altogether.

The general organ of sensation is the nervous system formed every where of the same medullary matter. In every species of animals, where the presence of this matter has been detected, it is divided into threads or filaments, which, proceeding from certain central points, are distributed throughout the body, and serve many important purposes, besides that of affording sensations. The centres from which these filaments proceed, communicate

municate in a more or less intimate manner, and there are many of the filaments which seem to have no other use but that of forming media of communication.

The nerves, or cords formed by the assemblage of a number of these filaments into a common bundle, when touched by any foreign substance, affect us with the sensation of pain; though the contact of those parts of the body, to which they are naturally contiguous, excites in them, in the state of health, no sort of sensation.

Particular organs are placed at the extremities of those nerves from which we derive our perceptions of the external world, and the conformation of the organ of sense is always in admirable adaptation to the particular nature of the object by which the nerve is to be impressed.

The general organ of motion is the fleshy or muscular fibre. This fibre contracts itself in obedience to the will; but the will exercises its power only through the medium of the nerves. There are no muscular fibres without nervous filaments, and the voluntary power over the muscles ceases entirely, when the communication of these filaments with the rest of the nervous system is intercepted. Several external agents, applied to the muscles, excite them to contraction,

contraction, and continue to produce this effect after the nerves have been divided, and even after the complete separation of the muscles from the body. This property of the muscular fibre has been called its *vis insita*, or irritability. It has been disputed among Physiologists, whether the irritability of the muscles, after their separation from the body, depends on the nervous matter which they still contain, and which cannot be separated from them ; or, whether in the action of the will itself, the nerve is not to be considered as a mere stimulus, acting on the inherent power of the fibre. The latter was the opinion of Haller, and of his school ; but every day seems to add farther probability to the doctrine of his opponents.

All the internal parts of the body, which exert any pressure upon the substances which they inclose, have their coats provided with muscular fibres and nervous filaments : as the arteries, alimentary canal, heart, &c. But the principal distribution of the muscular fibres is in the muscles. This is the name given to bundles of fleshy fibres, attached by their extremities to the moveable parts of an animal body. When the fibres shorten themselves, the two points into which the muscle is inserted, are brought nearer, and by this simple contrivance all the motions of animals are performed, and  
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their bodies transported from one place to another.

Animals that have no other mode of progressive motion but creeping, have their muscles inserted into different points of the skin, which they contract and dilate alternately; but animals, that move forward with greater speed, by distinct steps or leaps, have their muscles attached to certain hard parts, situated either externally or internally, which serve as levers, and move upon one another by centres of motion, called the joints or articulations.

The hard parts, when taken together, are called the skeleton; when covered by the muscles, they are called the bones; when external to the muscles, they get the names of shell, crust, scales, &c. according to their different degrees of hardness. In all cases, the hard parts surround and protect the proper viscera, and give form and proportion to the body.

The joints are provided with muscles for performing the motions for which they are adapted, every muscle pulling the bone to which it is attached in its own particular direction. The muscles may be considered as so many moving forces; and their strength, the distance of their insertion from the centre of motion, the length of the lever to which they are attached, and

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the weight connected with it, determine the duration and velocity of the motions which they produce. Upon these different circumstances depend, in the different species of animals, the force of their leap, the extent of their flight, the rapidity of their course, and their address in catching their prey ; but, it is still to be remembered, that the whole of this apparatus would remain without motion, if not animated by the nervous system.

The white and soft medullary substance, which constitutes the essential part of the nervous system, is divided into a vast number of small threads or filaments. These filaments are tied together in bundles or fasciculi, forming the nerves ; the gradual union of the nerves into one large fasciculus, is called the spinal marrow. At one extremity of the spinal marrow is placed the brain, that is, a mass of medullary matter, which varies much in size and form, in the different classes of animals.

We are not conscious of the impression of external objects upon our body, unless there be a free communication of nerves between the place where the impression is made and the brain. The ligature or division of the nerve, by intercepting the physical communication, intercepts also the sensation.

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There is but one sense, which belongs to every class of animals, and which is exercised over every part of the surface of the body ; the sense of touch. Its seat is in the extremities of the nerves distributed over the skin, and the same organ informs us of the resistance of bodies and of their temperature. The other senses would seem to be only more refined modifications of the sense of touch, and susceptible of more delicate impressions. Every one knows, that these senses are the sight, seated in the eye ; the hearing, seated in the ear ; the smell, seated in the internal membrane of the nose ; and the taste, seated in the tongue. These senses are very universally placed at that extremity of the body, which contains the brain, and is called the head.

The light, the vibrations of the air, the odorous effluvia floating in the atmosphere, saline particles or particles soluble in water or saliva, are the substances which act upon these four senses, and the organs, which transmit their action to the nerves, are admirably appropriated to the respective nature of each. The eye presents to the light a succession of transparent lenses, to refract its rays ; the ear opposes to the air, membranes and fluids, fitted to transmit its vibrations ; the nostrils, while they afford a passage to the air, in its way to the lungs, intercept any odorous particles which it contains ;

tains ; and the tongue is provided with spongy papillæ, for imbibing the sapid liquors, which are the objects of taste.

It is by these organs, that we are acquainted with what passes around us ; but, the nervous system gives us notice also of many changes, that take place within our own body. Internal pains warn us of the presence of disease ; and the disagreeable sensations of hunger, thirst, and fatigue, are signs of the body standing in need of refreshment or repose. It is also by means of the nervous system, that we experience desire, fear, pity, and the other emotions and passions of the mind ; but these are rather the effects of the re-action of the nervous system, than of immediate impressions on it from without. They are at the same time entirely independent of the will, and yet excite a variety of muscular motions in different parts of the body. Many effects of the nervous system depend on the numerous communications, which particular nerves, called Sympathetic, establish between the remoter branches of the general trunk of the nervous system, and through which impressions are transmitted with greater rapidity than by the brain. Those collections of nervous fibriles, which are called Ganglia, are a kind of secondary brain, and are observed to be larger and more numerous, in proportion as the principal brain is less.

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The faculties of sensation and of muscular motion, which, in the greater number of animals, are exclusively confined to the nervous and muscular fibres, seem to be universally diffused through the whole substance of some gelatinous animals, in whom neither nerve nor muscular fibre can be discovered.

It is by means of these two faculties that animals feel, desire, and are enabled to satisfy their wants. The most irresistible of these is hunger, which reminds them of the necessity of providing nutriment for their subsistence. The function of nutrition begins in the mouth, where the aliments are taken into the body, and where solids are broken down and moistened with saliva. From the mouth the food passes into the alimentary canal, which varies much in different animals in its length, width, and convolutions, and is surrounded by a number of coats, some of which are continued from and resemble the external teguments of the body.

The coats of the alimentary canal act mechanically upon the food by their power of muscular contraction, and act chemically by the liquors which they secrete.

The principal dilatation of the alimentary canal is called the stomach, and, in some species  
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of animals, there are more stomachs than one. The remaining part of the passages has the name of intestinal canal. From the internal coat of the stomach a secretion is poured out, which reduces the food to a homogeneous pulpy mass; and, in the intestines, besides the secretions which their own coats afford, there are liquors added to the food, which are separated from the common mass of blood by particular organs, and conveyed into the intestinal canal by appropriate ducts. The most important, and the most universal of these organs are the liver and the pancreas. The first especially, which forms the bile, is of considerable size; and the bile, besides its uses in the intestinal canal, conveys certain superabundant principles out of the blood.

In the intestinal canal the nutritive part of the aliment is extracted from it. In animals destitute of circulation, the nutritive particles pass by invisible pores through the coats of the digestive organs; but in animals of a more complicated structure, they are conveyed into the general circulatory mass, by a particular set of very delicate vessels. These vessels are the Absorbents, which, in man, and in the animals resembling him, are very distinct from the sanguiferous vessels, but approach gradually nearer to them in the inferior classes, and cannot be at all distinguished from them in the white blooded animals. Neither the absorbents nor sanguiferous  
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veins possess muscular fibres visible to the eye ; and both are provided with valves which allow their contents to pass in one direction only, that is, towards the heart. The arteries, on the contrary, are strong and muscular, but unprovided with valves, the violent impelling force of the heart being sufficient, without the aid of valves, to impress upon the arterial blood, motion in an uniform direction.

But, the chyle or liquid produced by digestion, is not sufficient to renovate the venous blood, and restore to it the faculty of nourishing the body ; the contact of air is necessary, before the blood can be returned with safety into the arterial system. This it is the business of respiration to effect. Where animals have a vascular system, the organ of respiration consists of a minute ramification of blood vessels, by which the surface is prodigiously multiplied, and every particle of blood is brought almost into contact with the surrounding element, nothing being interposed between them, except a thin membrane, which is insufficient to prevent their reciprocal action. In aquatic animals, this ramification of blood vessels is spread over the surface of certain thin laminæ, called *Gills* or *Branchiæ* : in animals that live in the air, a similar ramification of vessels surrounds a number of small cells which form the *Lungs*. Where there is no vascular system, the air penetrates into every part  
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of the animal, and acts upon the nutritive fluid at the instant when it is expended in the nourishment of the body. This is the case with insects that have *tracheæ*. In every variety of respiration, it is obvious, that muscular organs are required, to introduce and expell the air, and direct it to the place where the blood is prepared to receive its action. This is the office of the intercostals, diaphragm, and abdominal muscles in Man; of the opercula of the gills in fishes; and of various other parts in the different classes of animals.

In animals which have cellular lungs and breathe through a long and narrow tube, the formation of the voice is a subordinate use of respiration. For this purpose there are loose membranes stretchèd across a narrow part of the air tube, and the vibrations produced by the current of the air, form what is called the voice. Animals that have no voice, properly so called, are nevertheless, in many cases, able to produce sound; but this is effected by a mechanism of a totally different kind from that which forms the true voice.

The blood in its passage through the organ of respiration, experiences a species of combustion, which abstracts from it part of its carbon in the form of carbonic acid, and by that means increases the proportion of its remaining elements.

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The air is, at the same time, deprived of part of its oxygen, which is the only elastic fluid that can support respiration. The corresponding effects upon the blood are not yet fully understood. In animals with red blood, the colour of the blood is enlivened by respiration, and it acquires the power of exciting the action of the heart. There is reason even to believe, that it is through the action of the air upon the blood, that the muscular system derives its power of contraction. There are other means, besides respiration, of carrying off from the blood some of its component parts : many different substances are separated from it by the kidneys, which secrete the urine, and which are present in all red-blooded animals ; while other substances are discharged by perspiration, and along with the excrementitious part of the aliment. These three emunctories of the body serve, to a certain extent, as substitutes for one another, and appear to have so far a common tendency.

Such is the collection of organs that constitute an animal, and which would suffice for its individual existence, without any reference to the propagation of its species. Such, at least, are the organs possessed by animals of the higher classes ; for, the whole of these organs are far from being reunited in every species of animals. As we descend in the scale of Being, they disappear in succession, and at length, in the lowest and most

imperfect animals, we find nothing more than what is essential to the idea of animal life, a sentient self-moving sack, capable of digesting food.

When we inquire minutely into the action of these organs, we perceive that all the changes within animal bodies are effected by the combinations and decompositions of the fluids which they contain. The animal function by which one fluid is separated from another, or formed by the mixture and combination of elements derived partly from the one fluid, and partly from the other, is called *Secretion*. This appellation has, indeed, been usually confined to changes which take place in glands, that is, in bodies of various sizes, within which the blood vessels are minutely subdivided, and where, besides their usual terminations in the veins, they terminate in excretory ducts that convey the secreted liquor out of the gland. But, the animal economy presents us with a vast number of other mutations or separations of fluids which have an equal claim to the name of secretion. It is, indeed, hardly possible to conceive, that the nerves can excite the muscles to action, or external objects excite the organs of sense, without some chemical change, in the matter of which these parts are formed; and whatever be the nature of that substance on which the powers of the nervous system depend, it must be separated from the blood by the brain, or rather  
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by every part of the medullary organ. The blood itself is not perfectly elaborated till it has been purified from some of its principles in the lungs, the kidney, and the liver; and till it has received additional matter from the aliment; nor does the aliment afford chyle, till it has been mixed with various liquors secreted from the blood; and the blood nourishes the solids, through which it circulates only by the particles which are separated from it, while other particles are at the same time carried off from the solids, to be returned into the common mass of blood, by the absorbents.

In a word, all the animal functions are resolvable into transmutations of fluids, and the true secret of the animal economy lies hid in the manner in which these changes are effected, as health depends on their regularity and order.

In generation, the origin of the germ is concealed from us by its minuteness, so that we can pronounce nothing with respect to the manner of its production; but we find the feminal liquor to be a secretion, which, in animals that propagate by conjunction of sexes, is employed to excite the development of the germs; and the subsequent progress of the embryo, is a process of the same kind, and carried on by the same means as the ordinary growth of the body.

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The organs of generation, of which we have still to speak, are divided into those which prepare the feminal liquor, and apply it to the germ, and into those which contain and protect the germ during the first stages of its development. The former constitute the male, the latter the female sex.

The testicles are the glands for the secretion of semen, and several other glands prepare liquors to be mixed with it. The feminal canal passes along the under part of the penis, which serves to convey the semen into the vagina, or passage leading to the uterus or oviduct. The oviduct or Fallopian tube receives the embryo at the instant of its separation from the ovarium, and conducts it out of the body, if the animal be oviparous ; or into the uterus, if it be viviparous. The embryo is gradually developed, and draws its nourishment, either from the mother, by means of a spongy mass of vessels connected with the vessels of the mother, or from an organized mass called the egg. After it has arrived at the full term, it is forcibly expelled by the uterus, or it bursts the shell within which it had been shut up.



### CHAPTER III.

#### *View of the Principal Differences among ANIMALS, in their Systems of Organs.*

IT appears, from the preceding chapter, that what is common, in any system of organs, to all the classes of animals, is reducible to very little; and, that organs subservient to the same function, have often no other resemblance, than in their general effect. This is particularly the case with the function of respiration, which, in the different classes of animals, is exercised by organs, that, in structure, have absolutely nothing in common. The investigation of the differences in the structure of organs subservient to the same purpose, forms the proper object of comparative Anatomy; and the following rapid sketch of these differences may be considered as an outline of that science. We shall, therefore, resume the consideration of the different animal functions, and examine with what degree of energy they are exercised, and in what manner carried on by different animals.

The organs subservient to motion present us, in the first place, with two great and leading differences



differences, in their relative situations. The bones either form an internal, articulated skeleton, covered by the muscles; or, the muscles are placed internally, and surrounded by scales, or shells. There is still a third class of animals who are unprovided with hard parts, to serve as a lever or fulcrum for motion.

Animals of the first kind, have the body supported along its middle part, by a column formed of distinct pieces of bone, piled over one another, and called the spine of the back or vertebral column. The animals *with vertebræ* consist of four classes, the *Mammalia*, *Birds*, *Reptiles*, and *Fishes*.

Of the animals *without vertebræ*, the *soft worms*, are entirely destitute of hard parts; the *insects* have the body and limbs enveloped in scales, articulated together; and, lastly, the *Testacea* are inclosed within shells.

It is from the greater or less development of particular parts upon this general outline, that the different species of animals belonging to these classes are qualified to perform different kinds of motion.

In the organs of sensation, we meet with various important differences, some of which relate to the internal part of the nervous system, and others to the external senses.

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The differences in the internal part of the nervous system, present us with three well marked divisions : the first of which comprehends animals, in whom neither vessels nor nerves have been discovered, forming the class of *Zoophytes* or *Polypi* ; the second, consists of animals in whom the brain is placed above the alimentary canal, while the remaining part of the common medullary cord is placed beneath it, and, in the same cavity with the viscera, forming the classes of *Molluscæ*, *Crustacea*, *Insects*, and including part of the *articulated worms* ; the third division consisting of animals, in whom the common medullary cord is placed above the alimentary tube, towards the back, and inclosed within a canal formed by the vertebral column, constitute the class of animals with vertebræ. The nervous ganglia in this last class of animals, are either placed upon the sides of the spinal marrow, or scattered in the great cavities ; in the *Molluscæ* the ganglia are seated no where but in the great cavities ; in insects, and in some of the articulated worms, they are placed along, and appear to be enlargements of the common medullary cord.

The differences in the external senses relate either to their number, or to their goodness.

All the animals with vertebræ, have the same number of senses with man.

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The sense of sight is wanting in the Zoophytes, in many of the articulated worms, in many of the larvæ of insects, and in the acephalous Molluscæ. The organ of hearing has been discovered in a few only of the Molluscæ, and in some of the insects. The three remaining senses, but particularly the senses of touch and taste, seem to be present in every species of animals.

But, every one of the senses may differ much in its goodness, and in the greater or less complication of parts by which it is exercised. The perfection of the sense of touch, for example, depends on the delicacy of the external teguments, and on the divisions of the extremities of the body, which are more particularly employed in the exercise of touch; for, the more numerous these divisions are, the more accurately will the organ of touch be applied around external bodies. The number, and mobility of the fingers, and the smallness of the nails, form, in this respect, important characters for the Naturalist.

The eyes may be more or less mobile, more or less protected from external injury, more or less numerous. The ears may be sunk deep within the cranium, or placed more externally, or even provided with a kind of trumpet for collecting the sonorous undulations of air. The membrane of smell may be more

or less extensive ; the seat of taste more or less tender and moist ; but, details on these subjects would lead to the history of particular senses.

The organs of digestion present us in their general arrangement, with two remarkable differences. In the greater part of the Zoophytes, the intestines form a bag, which has but one opening, serving at once to admit the food, and to discharge the excrement. But, all other animals have two distinct openings for these purposes, placed at the two extremities of the alimentary canal, and situated at a greater or smaller distance from one another, according to the convolutions of that canal. Another difference in the organs of digestion, which has great influence on the kind of aliment adapted to them, consists in some animals having the mouth provided with teeth, or with some other hard part, for breaking down solid food ; while other animals are totally unprovided with such instruments, and must either swallow entire bodies if the mouth be large enough, or, suck up liquids if the mouth be in the form of a tube. The form of the teeth has great influence on the nature of the food which animals are able to masticate ; and the remaining part of the alimentary canal, has its conformation, in some measure, regulated by the food which it receives from the mouth : Hence, the more or less considerable length of the intestinal canal, the greater or smaller number

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of stomachs, of intestina cæca, and many other details foreign to the present view of the subject.

The chyle, formed by the action of the digestive organs upon the aliment, is transmitted to the rest of the body, in two different ways. It either passes through invisible pores in the coats of the intestinal canal, and transudes through every part of the body; or it is taken up by absorbent vessels, and carried into the general mass of blood. It passes by transudation in the Zoophytes; and also, according to Cuvier, in the insects, which appear to him to have no vessels appropriated for the circulation of the nutritive fluid. \* Among the animals which have absorbents, there are two farther differences to be observed. The animals with vertebræ have the blood red, and the chyle white or transparent; while the greater part by far of the Molluscæ have the blood and chyle of the same colour. The animals with vertebræ differ with respect to the colour of the chyle. Among the class Mammalia, it is of an opaque white; in birds, reptiles, and fishes, it is transparent, like lymph. The chyloferous vessels also, in the three last classes, have no conglobate glands connected with them, while these glands are very numerous in the class Mammalia.

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\* See a Memoir on this subject by Cuvier in the Journal de Physique T. XLIX.



In the organs employed for the circulation of the blood, there are very important differences. In the first place, there are animals which have no circulation, as the *Insects* and the *Zoophytes*; and in the second place, where the circulation exists, it is either single or double. The double circulation is that wherein no part of the venous blood can return into the arterial system, till it has made a complete circuit through the organ of respiration; which is in that case formed by the expansion of two large vessels, the one arterial, and the other venous, both nearly as large, though not so long, as the large vein and artery of the body. This is the circulation in Man, in the *Mammalia*, in *Birds*, in *Fishes*, and in many of the *Molluscae*.

The circulation is single, when a great part of the venous blood returns into the arterial system, without passing through the lungs, that organ being an expansion of a branch only of the principal artery. This is the circulation of *reptiles*.

Other differences exist in the number and position of the Hearts, or muscular organs employed to give an impulse to the blood. Where the circulation is single, there is but one heart; but where the circulation is double, there is sometimes one heart at the base of the

pulmonary artery, and another heart at the base of the principal artery ; while in other cases there is but one heart for both circulations.

Where there are two hearts or rather two ventricles, these either form a single mass, as in Man, in the Mammalia and in Birds ; or they are separated and placed at some distance as in the genus *Sepia*.

Where there is but one ventricle, it is either placed at the root of the principal artery of the body, as in *Snails*, and other molluscæ ; or at the root of the pulmonary artery, as in Fishes.

The organs of respiration are not less fruitful in important differences. Where the air is employed to act directly upon the blood, it is introduced into the interior of the organ of respiration ; but, where it acts through the medium of water, the water passes merely over the surface of that organ ; and the laminæ by which the surface is multiplied, are called the *gills* or *branchiae*. There are gills in fishes and in many of the molluscæ ; but in place of laminæ, the organ of respiration sometimes consists of loose fringes.

The air penetrates into the interior of the body, either by one opening, or by more openings than one. The first is the case with all animals.

animals, that have lungs, properly so called; and the tube which admits the air, is afterwards divided into a number of branches, that terminate in as many small cells, which are commonly united together into two separate masses, dilatatable and compressible at the pleasure of the animal.

When there are more openings than one, which is the case only with insects, the vessels that admit the air, spread by innumerable ramifications, through every part of the body. This is called respiration by means of *Tracheæ*.

Lastly, none of the Zoophytes, except the *Echinus*, *Asterias*, and other genera belonging to the same order, have any visible organs of respiration.

The organs of voice offer but two general differences, depending on the situation of the glottis, or part where the sound is formed. In birds, the glottis is placed at the bottom of the trachea or air tube, where it divides into two principal branches, one for each of the lungs. In quadrupeds and reptiles, the glottis is situated at the top of the trachea, and at the root of the tongue.

These three are the only classes of animals which are provided with a glottis; but there  
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are other animals which can produce sound, though by a mechanism of a different kind. Some employ for that purpose the friction of certain elastic parts; others employ the vibrations of certain parts in the air; while others impress a rapid motion on portions of air inclosed within some part of their body.

Generation presents us with two species of differences; one with regard to the mechanism by which it is effected, and the other with regard to its produce.

In a small number of animals, of which the whole belong to the class of Zoophytes, generation takes place without copulation, the young animal growing from the body of the adult, like a bud upon a tree. Other animals propagate their species by copulation only, and are consequently provided with the organs of two sexes. These are either placed in two separate individuals, or placed together in the same individual. The latter distribution is found among the Molluscæ and Zoophytes; insects and all animals with vertebræ, have the two sexes in two separate individuals.

Some hermaphrodite animals, such as the bivalve Testacea, have no occasion for the conjunction of two individuals, in order to produce offspring; whereas this is essentially necessary



in Snails and other species of molluscæ, that creep upon the belly, among whom each individual performs at one and the same time, the function of both male and female.

The offspring of generation is presented to us in three different forms. It is either a bud, projecting from the parent, and growing from it like the branch of a tree, till completely developed; or, it is a fœtus, which arrives at maturity in the uterus of its mother, where it is attached by vessels, and from which it comes out alive; or, it is an embryo, shut up within a shell, along with a substance connected to it by vessels, and which it converts into nourishment, before it is completely hatched. From these varieties, animals are said to be *gemmiparous*, *viviparous*, or *oviparous*. The *Gemmiparous* class are confined to a few Zoophytes and articulated worms. The *Viviparous* class includes Man and the other Mammalia. All other animals are *Oviparous*. In the Viper, the young come alive out of the mother, but it is because the eggs are hatched within the oviducts.

In the last place, when we attend to the changes of form, through which the young animal is obliged to pass, before it is fit to propagate its species, we find them reducible to two principal heads. Some animals have at birth



birth the same form which they afterwards retain, with the exception of a small number of inconsiderable parts, not fully developed, or which have not yet acquired their due proportion to the rest of the body.

Other animals are quite different in form at birth, from what they are in their perfect state, and have therefore not only to produce and develop new parts after birth, but must lose many of their original parts. These changes are called the *metamorphoses* of animals. They have been hitherto observed only among insects, and among reptiles without scales, that is in *Frogs* and *Salamanders*.

Such are the principal varieties in the organs appropriated to the different animal functions.

There is still indeed a very important difference to be remarked, which extends its influence over a great number of functions. It relates to the organs of secretion. In the four classes of animals with vertebræ, the organs of secretion are glands, or at least minute ramifications of blood vessels, the term Gland being strictly applicable to bodies only of a particular form and structure.

But this is not the case with insects, who have no other organs of secretion except tubes  
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of different lengths, which attract into the spongy texture of their coats, those particles that are to be separated from the general mass of the nutritive fluids:

Separate organs of secretion have not yet been discovered in the class of Zoophytes.

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#### C H A P. IV.

##### *View of the Relations that subsist between Variations in the Different Systems of Organs.*

SOME of the principal differences in the structure and action of the organs, which are appropriated to each of the animal functions, have been considered in the last chapter. A more minute examination of the subject would enable us to add considerably to the number of differences which was there stated ; but from the enumeration already made, it may be conceived what a vast number of combinations might be formed, corresponding to as many classes of animals, by uniting each separate modification of each particular organ, with all the modifications of the other organs in succession.

But many of these combinations, which in the abstract appear not impossible, cannot exist in nature, because the organs of a living body are not related, by their juxtaposition merely in the same subject, but also by their reciprocal action upon one another, and by their concurrence in producing a common effect. In consequence of this mutual influence of the different organs, the modifications of any one organ af-  
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fect the modifications of every other organ. Such of these modifications as cannot co-exist in the same individual, may be regarded as mutually exclusive ; while there are other modifications that reciprocally imply, as it were, each others existence. These observations will be found applicable, not only to organs which are directly and obviously related, but even to those which appear, at first sight, to be the most remote and the least connected.

In fact, there is not a single function, which does not require the assistance and co-operation of all the other functions, and which is not affected by the degree of energy with which the other functions are exercised.

Respiration, for example, cannot be carried on, without the motion of the blood ; for the office of respiration is to bring every particle of the blood into contact with the air or the water that surrounds the animal body ; and, therefore, since it is the circulation which gives motion to the blood, the circulation becomes a necessary step towards respiration.

The circulation itself depends on the muscular action of the heart and arteries, and therefore cannot be carried on without the aid of muscular irritability. This faculty again would remain inert, without the nervous system,

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which brings us back to the circulation of the blood, the source of every secretion, and consequently of the matter composing the nerves.

How limited would have been the faculty of sensation, if it had not been aided by the muscular power? Of what use would have been the sense of touch, if the hand could not have been employed for the examination of external bodies? How confined would have been the perceptions of vision, if we had possessed no power of turning the head, or of moving the eyes?

Upon this mutual dependance of the functions, upon this reciprocal aid which they receive and which they bestow, depends a system of laws, which regulate the relations of living organs, and which are themselves founded on the same necessary relations as the laws of metaphysics or of mathematics; for it is self evident, that a suitable harmony among organs, which are to act upon one another, is a necessary condition for the existence of the Being to which they belong, and that if one of its functions were modified in a manner incompatible with the modifications of the other functions, that Being could not exist.

We shall take a cursory view of some of the more important of these relations, and for that purpose



purpose compare together, two by two, the different functions of animals.

To begin with one of the most obvious of these relations, it is manifest, that the mode of respiration in different animals, must vary with the manner in which the motion of the nutritive fluid is carried on. In animals where there is a heart and vascular system, the nutritive fluid is continually collecting in a central reservoir, from which it is projected with force to every part of the body. It is passing continually from the heart to the extreme vessels, and returning from the extremities to the heart. It is possible, then, to expose the whole nutritive fluid to the air, at the very source of its motion in the heart ; and, accordingly, in these animals, before the nutritive fluid is conveyed by the arteries to the distant parts of the body for nutrition, it is circulated through the lungs or gills, where it receives the action of the air. But, a difference of structure in the organs of respiration becomes necessary in animals, which, like the insect tribe, have neither heart nor blood-vessels. As the nutritive fluid of these animals has no regular motion, and proceeds not from any common source ; but transudes, like dew, through the coats of the alimentary canal, and, diffusing itself throughout the body, supplies every part with nourishment ; it is impossible to prepare it  
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for nutrition, in a separate organ, before its general distribution through the body. The action of the air must therefore be exercised, at the place and at the instant of the intussusception of nutritive particles; and this is completely effected in these animals by the arrangement of the tracheæ or air vessels, the minute ramifications of which are distributed through every part of the body, and supply air wherever its chemical action is wanted.

Since we perceive distinctly in these instances the causes of the relations which we find subsisting between the organs of circulation and those of respiration, we are authorised to presume, that other correspondences in structure which we find equally constant, are equally necessary, though we should be unable to trace the connection. Thus, among animals having blood vessels and a double circulation, those which respire air directly, by receiving it into the lungs, are observed to have always the trunks of the two principal arteries placed close to one another, and provided with two fleshy ventricles, united into a single mass; whereas animals that breathe by the intervention of water, which they compress between the laminae of the gills, have always the trunks of the two principal arteries separated, and placed at some distance; and this is observed to be the case, whether each of the principal arterial trunks be  
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provided with a separate ventricle, as in the genus *Sepia* ; or, whether one of them only be furnished with a ventricle, as in the rest of the Mollusca and in Fishes.

We perceive more clearly the nature of those relations which connect together the extent and mode of respiration in different animals, with their locomotive faculties ; and which render air so much the more necessary to animals, in proportion as their modes of life enable them to procure it in the greatest abundance. In other words, the animals which can get pure air with the greatest facility, are precisely the animals which are in the greatest dependance on respiration.

Modern experiments have shown, that one of the principal uses of respiration, is to reanimate the muscular power, by recruiting the exhausted irritability of the muscular fibre. We accordingly observe, that, among animals which respire air directly, those possessed of a double circulation, and in whom no particle of venous blood can return to the solids, till it has passed through the organ of respiration, (the class of Birds and the class of Mammalia,) not only live continually in the air, and perform muscular motions of far greater strength than other red-blooded animals ; but, likewise, that each of these classes enjoys the muscular power precisely in that degree which corresponds



corresponds to its respiration. Birds live continually in the air, and are as completely immersed in it within the body, as they are without; for, not only is the cellular part of the lungs, in Birds, very large, but there are air-bags or appendages to the lungs, diffused through every part of the body. Birds, accordingly, consume, in proportion to their size, a greater quantity of air, in a given time, than Quadrupeds; and, it is this undoubtedly, which gives to the muscular fibre of Birds, that prodigious and rapid force of contraction, which fits it to be the moving power in machines, that must be supported in the air by the mere vibrations of wings.

In the force of muscular motion, and in the quantity of air consumed by respiration, the class of Mammalia hold a middle place between Birds and Reptiles, two classes of animals, which may be justly opposed to one another. Respiration appears, in the class of Reptiles, to be a subordinate or accessory function only. Reptiles can exist without respiration as long very nearly as they please. Their pulmonary vessels are branches only of the great arterial trunk. Accordingly, while upon the one hand, their organs of motion oblige them to remain upon the ground, in obscure and stifled places, and in the midst of miasmata: and while their instinct leads them to shut themselves up in caverns, where the air is never renewed, or to immerse themselves under water  
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for a great part of the year ; on the other hand, their motions are very generally slow and languid, and they pass the greater part of their existence in a state of nearly absolute repose.

Farther, as it is one of the conditions essential to the existence of every animal, that its physical wants be not greater than its means of satisfying them, so it is observed in the class of Reptiles, that in proportion as the respiration is less prompt, and less efficacious to recruit the irritable power, so much the less easily is the irritability exhausted. It is from this cause that the muscles of Reptiles are so tenacious of irritability, and palpitate so long after their separation from the body, while the muscles of warm-blooded animals lose their irritability as they cool.

This relation between the energy of the muscular power and the degree of action in the surrounding element, is confirmed by the example of Fishes, who having, like Reptiles, the blood cold, have also, like them, very little muscular power, and an irritability not speedily exhausted. In judging of the muscular power of Fishes, we must not allow ourselves to be deceived by the velocity with which some of these animals are known to swim ; for being placed in an element of the same specific gravity with themselves, they are supported in it without any exertion of their own.

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But, if the respiration of Fishes be productive of the same consequence as the respiration of Reptiles, the effect is obtained by different means. As it is only the small quantity of air dissolved in water, which has access to the blood in Fishes, it becomes necessary that the inconsiderable effect produced by a single circulation through the gills, should be compensated by the quick return of the blood, and therefore the circulation of Fishes is double, like that of warm-blooded animals. We discover, in this instance, a new relation between the modifications of the organs of respiration and the organs of circulation. Animals, to whatever class they belong, if they respire by gills and through the medium of water, have a double circulation; whereas, among animals who respire air, there are many who have the circulation single, that is, all animals who require not a great degree of muscular power. But, as the combination is no where to be found, of a single circulation with respiration by gills, it may be concluded, that this combination would reduce too low the efficacy of respiration, and render it unfit to support the muscular power.

The relations of the nervous system to the respiration appear from the varieties in each which are observed to correspond. The external senses are much less energetic, and the brain is of much inferior magnitude, in cold-blooded animals, where it occupies only a part of the cavity  
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of the cranium, than it is in warm-blooded animals, where it fills the whole of that cavity. The inconsiderable degree of muscular power which can be exerted by the muscular fibre in cold-blooded animals is, perhaps, the reason why so little active power is given to the organ which excites it to contraction. Lively sensations and violent passions, would have too powerfully exhausted the irritability of the muscles. By this circuitous channel, then, the modifications of the organs of sense are connected with the modifications of the organs of respiration.

But, from what secret cause does it proceed, that in all animals, who respire by a particular organ, the masses of medullary matter are few in number, and collected within the cranium, or at least distinct from the spinal marrow; whereas, in animals that breathe by tracheæ, there are numerous ganglia, of nearly equal sizes, arranged at small distances along the whole length of that cord? And why, in the structure of animals, who have no organ particularly appropriated for respiration, is there no appearance of a nervous system to be traced? Both these relations are still inexplicable.

Digestion is another function, not without its relations to respiration. For, respiration being the function, which consumes and carries off with the greatest rapidity, the substance of which the body is composed, the digestive organs require

quire to be more powerful in proportion as the respiration is more active, in order that the quantity of matter introduced into the body may be equal to the quantity of matter evacuated from it.

It is through the medium of these connections between the modifications of the organs of respiration, and those of the organs of the other functions, that some of the latter acquire relations to one another, which are not otherwise easily explicable. Birds have, in general, a very powerful stomach, and a very quick digestion. Birds make very frequent meals ; while reptiles, who, in every particular, appear, of red-blooded animals, to be the Antipodes of Birds, astonish us by the small quantity of aliment which they consume, and by the length of the fasts which they endure. It is not so much through the organs of motion, in these two classes of animals, that these differences in the organs of digestion are rendered necessary, as through the organs of respiration, the modifications of which, again, have a direct relation to those of the organs of motion.

It is evident, that these two very different degrees of digestive force must depend on two equally distinct dispositions in the organs of digestion; and that neither of them could co-exist in the same individual, but with its corresponding



ing disposition in the organ of respiration. The organ of respiration, again, being connected by relations equally constant with the organs of motion, the organs of sensation, and the organs of circulation, it follows, that all the five systems of organs are governed and directed by each system in particular.

But, besides this indirect connection, the system of digestive organs has direct relations to the organs of motion and of sensation ; for, the structure and disposition of the digestive organs necessarily determines the kind of aliment proper for every species of animals ; and, it is obvious, that if the senses and organs of motion in any species of animals be insufficient to distinguish, and procure for them their proper aliment, that species of animals cannot subsist.

Thus, animals who can digest nothing but flesh, must, under the penalty of inevitable destruction, be able to discern their prey at a distance, to pursue it, to catch it; to get the better of it, to tear it in pieces. They must, therefore, possess a piercing eye, an acute sense of smell, swiftness in pursuit, address and force in the organs for catching their prey. Accordingly, a canine tooth, adapted to tear flesh, was never found, in the same animal, along with a hoof; fit for supporting the weight of the body, but totally unqualified for laying hold of prey. Hence, the rule that every hoofed animal is herbivorous, and

and as corollaries from this general principle, the maxims that a hoofed foot indicates grinding teeth with flat surfaces, a long alimentary canal, a large stomach, and often more stomachs than one, with many other similar consequences.

The laws, which regulate the relations between different systems of organs, have the same influence on the different parts of the same system, and connect together its different modifications, by the same necessary principles. In the alimentary system especially, where the parts are large and numerous, these rules have their most striking applications. The form of the teeth, the length, the convolutions, the dilations of the alimentary canal, the number and abundance of the gastric liquors, are in the most exact adaptation to one another, and have similar fixed relations to the chemical composition, to the solid aggregation, and to the solubility of the aliment; in so much that from seeing one of these parts by itself, an experienced observer could form conclusions tolerably accurate, with respect to the conformation of the other parts of the same system, and might even hazard more than random conjectures with respect to the organs of other functions.

The same harmony subsists among the different parts of the system of organs of motion. As all the parts of this system act mutually, and are acted upon, especially when the whole body of  
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of the animal is in motion, the forms of all the different parts are strictly related. There is hardly a bone that can vary in its surfaces, in its curvatures, in its protuberances, without corresponding variations in other bones; and in this way, a skilful Naturalist, from the appearance of a single bone, will be often able to conclude, to a certain extent, with respect to the form of the whole skeleton to which it belonged.

These laws of co-existence, which have just been indicated, are deduced by reasoning from our knowledge of the reciprocal influence of the functions, and of the uses of the different organs of the body. Having confirmed them by observation, we are enabled, in other circumstances, to follow a contrary route; and when we discover constant relations of form between particular organs, we may safely conclude, that they exercise some action upon one another; and we may thus be frequently led to form just conjectures with respect to their uses. For example, the remarkable size of the liver in animals, where the respiration is inconsiderable, and the total absence of that viscus in insects, where the respiration is the most complete that can be imagined, since every part of the body is a kind of pulmonary organ, have given rise to the conjecture, that the liver performs, to a certain extent, the same office with  
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the lungs, by carrying off from the blood some part of its combustible elements.

Guided by the same spirit of analogy, we should be led to explain the whiteness and opacity of the chyle, in particular animals, while in the greater part it is transparent, when we are told that the animals in whom the chyle is white, are those animals precisely that have breasts, and secrete milk for the nourishment of their young. It is, indeed, chiefly from the attentive study of these relations, and from the discovery of relations which have hitherto escaped our notice, that Physiology has reason to hope for the extension of her limits; and accordingly the comparative anatomy of animals is one of the most fruitful sources to her of valuable discovery.

In the last place, Nature, while confining herself strictly within those limits which the conditions necessary for existence prescribed to her, has yielded to her spontaneous fecundity wherever these conditions did not limit her operations; and without ever passing beyond the small number of combinations, that can be realised in the essential modifications of the important organs, she seems to have given full scope to her fancy, in filling up the subordinate parts. With respect to these, it is not inquired, whether an individual form, whether a particular

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lar arrangement, be necessary ; it seems often not to have been asked, whether it be even useful, in order to reduce it to practice : it is sufficient, that it be possible, that it destroy not the harmony of the whole. Accordingly, as we recede from the principal organs, and approach to those of less importance, the varieties in structure and appearance become more numerous ; and when we arrive at the surface of the body, where the parts the least essential, and whose injuries are the least momentous, are necessarily placed, the number of varieties is so great, that the conjoined labours of Naturalists have not yet been able to give us an adequate idea of them.

In the number of these combinations, there are necessarily many which have parts in common, and there are always some which differ but little, so that by placing in succession those which have the greatest resemblance, it is possible to construct a kind of series or scale, that shall appear to recede gradually from a primitive model. It is this view of the subject, which has suggested to certain Naturalists the idea of the scale of Being ; by which is meant, that all Beings may be placed in a series or scale, beginning with the most perfect, and terminating in the most simple, or in the one which possesses qualities the least numerous and most common, so that the mind in passing along the scale, from one Being to another, shall

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be

be nowhere conscious of any chasm or interval, but proceed by gradations almost insensible. In reality, while we confine our attention within certain limits, and especially while we consider the organs separately, and trace them through animals of the same class only, we find them proceed, in their degradation, in the most uniform and regular manner, and often perceive a part, or vestige of a part, in animals where it is of no use, and where it seems to have been left by Nature, only that she might not transgress her general law of continuity.

But, on the one hand, all the organs do not follow the same order in their degradation. *This* organ is at its highest state of perfection in one species of animals; *that* organ is most perfect in a different species; so that, if the species are to be arranged after each particular organ, there must be as many scales or series formed, as there are regulating organs assumed; and in order to construct a general scale of perfection, applicable to all Beings, there must be calculation made of the effect resulting from each particular combination of organs—a calculation which it is needless to add, is hardly practicable.

On the other hand, these slight shades of difference, these insensible gradations continue to be observed, only while we confine ourselves to the same

same combinations of leading organs, only while we direct our attention to the same great central springs. Within these boundaries all animals appear to be formed on one common plan, which serves as the groundwork to all the lesser internal modifications: but the instant we pass to animals, where the leading combinations are different, the whole of the resemblance ceases at once, and we cannot but be conscious of the abruptness of the transition.

Whatever separate arrangements may be suitable for the two great classes of animals, with and without vertebræ, it will be impossible to place at the end of the one series, and at the commencement of the other, two animals sufficiently resembling to form a proper bond of connection.

CHAP.

## CHAPTER V.

### *Classification of Animals from their internal Organization.*

ANIMALS may be divided into the two great families of animals with vertebræ and red blood, and of animals without vertebræ, and most of them with white blood.

The former have always an internal articulated skeleton, of which the chief connecting part is the vertebral column. The anterior part of this column supports the head ; the canal which passes from one end of it to the other, incloses the common fasciculus of the nerves ; its posterior extremity is most frequently prolonged, in order to form the tail ; and its sides are articulated with the ribs, which are seldom wanting. None of this family of animals has more than four limbs, some of them have two only, and others have none.

The brain is always inclosed in a particular osseous cavity of the head, called the cranium. All the nerves of the spine contribute filaments to form a nervous cord, which has its origin in  
the



the nerves of the cranium, and is distributed to the greater part of the viscera.

The senses are always five in number. There are always two eyes, moveable at pleasure. The ear has always at least three semicircular canals. The sense of smell is always confined to particular cavities in the fore part of the head.

The circulation is always performed by one fleshy ventricle at least; and where the ventricles are two in number, they are always close together, forming a single mass. The absorbent vessels are distinct from the sanguiferous veins.

The two jaws are always placed horizontally, and open from above downwards. The intestinal canal is continued without interruption, from the mouth to the anus, which is always placed behind the pelvis, that is, behind the circle of bones, which affords a fixed point for the posterior extremities. The intestines are enveloped within a membranous sac, termed peritonæum. There is always a liver and a pancreas, which pour their secretions into the cavity of the intestines; and there is always a spleen, within which part of the blood undergoes some preparatory change, before it is sent to the liver.

There

There are always two kidneys for the secretion of urine, placed on the two sides of the spine, and without the peritonæum. The testicles also are always two in number. There are always two bodies, called atrabiliary capsules, placed over the kidneys; the use of them is unknown.

Animals with vertebræ are subdivided into two branches, one of which is warm-blooded, and the other cold-blooded.

Vertebrated animals with warm blood, have always two ventricles, and a double circulation. They respire by means of lungs, and cannot exist without respiration. The brain fills exactly the cavity of the cranium. The eyes are covered with eye-lids. The tympanum of the ear is sunk within the cranium; the different parts of the labyrinth are completely inclosed within bone; and, besides the semicircular canals, the labyrinth contains the cochlea with two *scalæ*, resembling the shell of the snail. The nostrils always communicate with the throat, and afford a passage for the air of respiration. The trunk is furnished with ribs, and almost all the species of this branch of animals have four limbs.

Vertebrated animals with cold blood, resemble one another more by their negative, than by their positive characters. Many of them are  
destitute

destitute of ribs ; some of them are totally destitute of limbs. The brain does not fill the whole cavity of the cranium. The eyes seldom have moveable eye-lids. The tympanum of the ear, when present, is always close to the surface of the head ; it is often wanting, as are likewise the ossicula auditus ; the cochlea is always wanting. The different parts of the ear are not firmly attached to the cranium ; they are often loosely connected with it, and in the same cavity with the brain.

Each of these two branches is subdivided into two classes.

The two classes of warm-blooded animals are the *Mammalia* and *Birds*.

The *Mammalia* are viviparous, and suckle their young with milk secreted by the mammæ. The females have consequently always the cavity termed Uterus, with two cornua ; and the males have always a penis *intrans*.

The head is supported on the first vertebra by two eminences. The vertebræ of the neck are never less than six, nor more than nine. The brain has a more complicated structure than in other animals, and contains many parts which  
are

are not to be found in the other classes, such as the corpus callosum, fornix, pons, etc.

The eyes have two eye-lids only. The ear contains four small bones, articulated together, and has a spiral cochlea. The tongue is quite soft and fleshy. The skin is covered entirely with hairs, in the greater number, and in all, it is covered partially.

The lungs fill the cavity of the chest, which separated from the abdomen by a fleshy diaphragm. There is one larynx only, situated at the basis of the tongue, and completely covered by the epiglottis, when the animal swallows.

The lower jaw only is moveable. Both jaws are covered with lips.

The biliary and pancreatic ducts are inserted into the intestinal canal at the same place. The lacteal vessels convey a white milky chyle, and pass through a number of conglobate glands, situated in the mesentery. A membrane called omentum, suspended from the stomach and adjacent viscera, covers the fore part of the intestines. The spleen is always upon the left side, between the stomach, ribs, and diaphragm.

*Birds* are oviparous. They have only one ovarium, and one oviduct, in which they differ from



from other oviparous animals. The head is supported on the first vertebra of the neck by a single eminence. The vertebræ of the neck are very numerous, and the sternum very large. The anterior extremities are used for flying, and the posterior for walking.

The eyes have three eye-lids. There is no external ear; the tympanum contains only one bone; and the cochlea is a cone slightly curved. The tongue has a bone internally. The body is covered with feathers. The lungs are attached to the ribs. The air passes through the lungs, in its way to the air bags, which are dispersed throughout the body. There is no diaphragm. The trachea has a larynx at each end, and the upper one has no epiglottis. The mouth consists of a horny bill without lips, teeth or gums, and both mandibles are moveable.

The pancreas and liver send out several excretory ducts, which enter the intestines at different places. The chyle is transparent, and there are no mesenteric glands, nor omentum. The spleen is in the center of the mesentery. The ureters terminate in a cavity called the cloaca, which also affords an exit to the solid excrement, and to the eggs. There is no urinary bladder.

The two classes of cold-blooded animals are the *Reptiles* and *Fishes*.

The *Reptiles* differ from one another in many very essential particulars, and have not so many characters in common as the other classes. Some of the *Reptiles* walk, some fly, some swim, many can only creep. The organs of the senses, and particularly the ear, differ almost as much as the organs of motion; none of the *Reptiles*, however, have a cochlea. The skin is either naked, or covered with scales. The brain is always very small. The lungs are in the same cavity with the other viscera; there are no air-bags beyond the lungs; but, the cells of the lungs are very large. There is but one larynx, and no epiglottis. Both the jaws are moveable. There are neither mesenteric glands, nor omentum. The spleen is in the center of the mesentery. The female has always two ovaria, and two oviducts. There is a bladder. \*

*Fishes* respire by means of organs, in the shape of combs, placed at the two sides of the neck, between which they force water to pass. They have, consequently, neither trachea, larynx, nor voice. The body is formed for swimming. The  
fins

\* The class of *Reptiles* in the arrangement of Cuvier, correspond to the orders of *Reptiles pedati*, and *Serpentes apodes*, belonging to the class of *Amphibia*, in the *Systema Naturæ* of Linnæus.

fins are sometimes wanting : besides the four, which correspond to the limbs, they have vertical fins upon the back, under the tail, and at its extremity.

The nostrils are not employed in respiration. The ear is quite hid within the cranium. The skin is naked, or covered with scales. The tongue is osseous. Both jaws are moveable. There are often cæca in place of the pancreas. There is a bladder, and two ovaria. \*

The animals destitute of vertebræ have less in common, and form a less regular series than the vertebrated animals. But, when they have hard parts, these are generally placed on the outside of the body, at least when articulated ; and the nervous system has not its middle part inclosed within a canal of bone, but loosely situated in the same cavity with the other viscera.

The brain is the only part of the nervous system which is placed above the alimentary canal. It sends out two branches, which encircle the oesophagus, like a necklace, and which afterwards unite and form the common fasciculus of the nerves.

None

\* The class of *Fishes* include the *Fishes* and the *Amphibia Nantes* of Linnæus.

None of the animals without vertebræ respire by cellular lungs, and none of them have a voice. Their jaws are placed in all kinds of directions, and many of them have only organs of suction. None of them have kidneys, or secrete urine. Those among them which have articulated members, have always six at least.

Considered anatomically, these animals may be distributed into five classes.

The *Mollusca* form the first class.

The body of the Mollusca is fleshy, soft, and without articulated members, though sometimes containing hard parts internally, and sometimes covered completely by hard shells. They have arterial and venous vessels, within which the blood undergoes a true circulation.

They respire by branchiæ. The Brain is a distinct mass, from which the nerves and medulla oblongata proceed. There are ganglia in different parts of the body.

The internal senses vary as to their number. Some of the Mollusca have the organs of sight and hearing quite distinct, while others seem to be confined to the senses of touch and taste. Many of them can masticate their food; others have the power of swallowing only.

They



They have a very large liver, which affords a great quantity of Bile. The organs of generation vary extremely.\*

The *Crustacea* form the second class.

The body is covered with a hard crust, in separate pieces. There are articulated limbs, which are often very numerous. The nervous system consists of a long, knotted cord, from the ganglia of which proceed all the nerves.

The eyes are compound, hard, moveable. The Ears are very imperfect. For the sense of touch, the Crustacea have antennæ and palpi, like insects. They have a heart, arterial and venous vessels, and branchiæ for respiration. The jaws are transverse, strong and numerous. The stomach has teeth within. The numerous cæca afford a brown liquor, which seems to be in the place of Bile. The penis is double, and there are two ovaria. †

The *Insects* form the third class.

In

\*The class of *Mollusca* comprehend the greater part of the animals, whom Linnæus has arranged in the two orders of *Mollusca* and *Testacea*, in the class of *Vermes*; such as the *Sepia*, *Limax*, *Ascidia*, *Helix*, *Ostrea*, *Patella*, *Pholas*, *Teredo*, etc.

† The *Crustacea* include the genus *Cancer* and the genus *Monoculus* of Linnæus.

In their perfect state they have, like the Crustacea, articulated limbs and antennæ. Most of them have also membranous wings, which enable them to fly. All these last pass through several metamorphoses, in one of which they are quite destitute of the power of motion. All of them have a nervous system similar to that of the Crustacea ; but insects have neither heart nor blood vessels, and respire by tracheæ. Not only the liver, but all the secreting organs are wanting, and their place is supplied by long vessels, which float loosely in the abdomen. The form of the intestinal canal is often very different in the same individual, in its three different states.\*

The animals which resemble the larvæ of insects, and have, like them, the medullary cord knotted, may be placed in the same class with insects, though they undergo no metamorphosis ; but there are some of that number, which have distinct sanguiferous vessels, and which must be arranged in a separate class, intermediate between

\* The class of *Insects* corresponds to the same class in the *Systema Naturæ*, with the exception of the two genera separated from it, in order to form the class of Crustacea.

tween the Mollusca, Crustacea, and Insects. To this class belong *Earth worms* and *Leeches*. \*

This being the fourth class, the *Zoophytes* will form the fifth.

The *Zoophytes* have the parts of their body placed in a star-like form, proceeding like the radii of a circle from the center, where the mouth is placed. They have neither heart, nor vessels; nor has there been discovered in them a nervous system. †

\* The class of *Worms* comprehends some of the genera, arranged by Linnæus among the *Vermes Intestina*, such as the *Lumbricus*, *Gordius*, *Hirudo*; some of the genera placed by the same Naturalist among the *Vermes Mollusca* such as the *Aphrodita*, *Nereis*, *Terebella*; and lastly some genera included in his order of *Vermes Testacea*, such as the *Serpula*, *Dentalium*.

† The class of *Zoophytes* correspond to the *Zoophyta* and *Lithophyta* of Linnæus; but also include some of the *Vermes Mollusca*, such as the *Echinus*, *Asterias*, *Holothuria*, *Actinia*, *Medusa*, together with the genus *Sipunculus* from the *Vermes Intestina*.

## CORRIGENDA.

- p. 1.  
3 12 *for* had been, *read* was.  
7 2 — they are afterwards to devolope, *read* are to be  
afterwards developed.  
9 7 — of a different kind, *read* regulated by laws essentially different.  
8 — renew the attempt, *read* engage anew in the investigation.  
11 9 — these, *read* the.  
24 26 — the, *read* these.  
25 18 — all, *read* both.  
32 16 — loose, *read* tense.  
47 20 — includes, *read* include.  
Throughout the 3d chap. for Molluscæ, read Mollusca.



L. M Geo. Bell

With best respects from  
the Author

Edinburgh the 12<sup>th</sup> Aug<sup>r</sup> 1801





